



Fundamental cavity-waveguide interplay in cavity QED

Denning, Emil Vosmar; Iles-Smith, Jake; Østerkryger, Andreas Dyhl; Gregersen, Niels; Mørk, Jesper

Publication date:
2018

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):
Denning, E. V., Iles-Smith, J., Østerkryger, A. D., Gregersen, N., & Mørk, J. (2018). *Fundamental cavity-waveguide interplay in cavity QED*. Paper presented at International Conference on Integrated Quantum Photonics, Paris, France.

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Fundamental cavity-waveguide interplay in cavity QED

Emil V. Denning¹, Jake Iles-Smith^{1,2}, Andreas Østerkryger¹, Niels Gregersen¹, Jesper Mørk

¹*Department of Photonics Engineering, DTU Fotonik, Technical University of Denmark, Building 343, 2800 Kongens Lyngby, Denmark*

²*Photon Science Institute and School of Physics and Astronomy, The University of Manchester, Oxford Road, Manchester, M13 9PL, United Kingdom*

Interfacing solid-state emitters with photonic structures is a key strategy for developing highly efficient photonic quantum technologies [1]. Such structures are often organised into two distinct categories: nanocavities and waveguides. However, any realistic nanocavity structure simultaneously has characteristics of both a cavity and waveguide, which is particularly pronounced when the cavity is constructed using low-reflectivity mirrors in a waveguide structure with good transverse light confinement. In this regime, standard cavity quantum optics theory breaks down, as the waveguide character of the underlying dielectric is only weakly suppressed by the cavity mirrors.

In this work [2], we present a quantum optical model that captures the transition between a high-Q cavity and a waveguide, allowing consistent treatment of waveguides, lossy resonators, and high quality cavities. Our model constitutes a bridge between highly accurate optical simulations of nanostructures [3] and microscopic quantum dynamical calculations. This way, the quantum properties of generated light can be calculated, while fully accounting for the electromagnetic properties of the nanostructure. The generality of this theory enables us to identify an optimal regime of operation for quantum dot single-photon sources, which simultaneously harnesses the high efficiency of a waveguide and the phonon-suppressing spectral structure of a cavity [4,5].

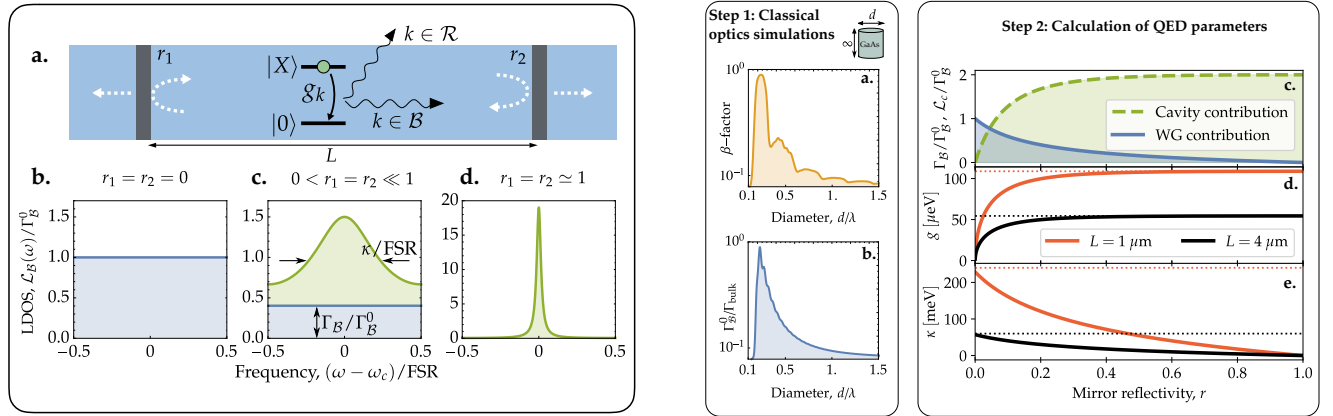


Figure 1: **(Left) a.** Schematic of a two-level emitter in a waveguide structure with two mirrors forming a Fabry-Perot cavity. **b–d.** Optical local density of states (LDOS) vs. frequency, scaled with the free spectral range (FSR), at the position of the emitter for mirrors with weak, intermediate and high reflectivity, respectively. **(Right) a, b.** β -factor and spontaneous emission rate into infinitely long waveguide. **c.** Cavity and waveguide contributions to LDOS when mirrors are introduced to the structure. **d, e.** Cavity-emitter coupling rate and cavity decay rate.

References

- [1] P. Lodahl, S. Mahmoodian, and S. Støbbe, *Rev. Mod. Phys.* **87**, 347 (2015).
- [2] E. V. Denning *et al.*, arXiv:1804.01364 (2018)
- [3] J. R. de Lasson *et al.*, *Optics Express* **26**, 11366 (2018)
- [4] J. Iles-Smith, D. P. S. McCutcheon, A. Nazir, and J. Mørk, *Nat. Phot.* **11**, 521 (2017).
- [5] T. Grange *et al.*, *Phys. Rev. Lett.* **118**, 253602 (2017).